

Design of a Robust Fiber Optic Communications System for Future IceCube Detectors

IceCube Collaboration (Rob Halliday), ICRC 2021

What is this contribution about?

- Design of a new hybrid fiber/copper communications system for possible large scale future neutrino detectors such as IceCube-Gen2
- Timing and bandwidth capacity concerns for such a system
- Ensuring mechanical robustness and redundancy for in-ice fiber optics

Why is it relevant / interesting?

- IceCube's current signaling protocol will not easily extend to larger detectors
- New optical modules are leaning on multi-PMT designs, thereby increasing bandwidth capacity requirements
- A hybrid fiber/copper system can solve these problems and deliver extra bandwidth capacity and very precise timing for future modules and science goals

What has been done?

- We have laid out the building blocks and a detailed plan for this hybrid communications system:
 - a new copper + fiber integrated main cable,
 - a breakout and penetrator assembly capable of delivering White Rabbit timing and ethernet and a
 - Field Node timing, data and power distribution hub to handle traffic on the White Rabbit interface and finally,
 - a short copper run from the Field Node to individual sensors.
- We have tested the redundancy of various fiber network topologies within the hybrid main cable and found that optimizations can provide wide redundancies allowing even as much as 23% of fibers to break before losing any sensor connections.
- The mechanical elements of the design have been chosen to minimize the possibility of any fiber breakage. These elements include ruggedized optoelectronics and armored fibers.

What is the result?

- A pathfinder Fiber Test System will be deployed to collect critical design validation data for the hybrid main cable, breakout + penetrator combination and Field Nodes (the short run copper connection is considered very low risk).
- This system meets and exceeds all bandwidth and timing requirements and builds in a large degree of redundancy, making a future hybrid system feasible. The excess bandwidth and timing performance allow for yet-to-be-planned science goals and detector technologies.

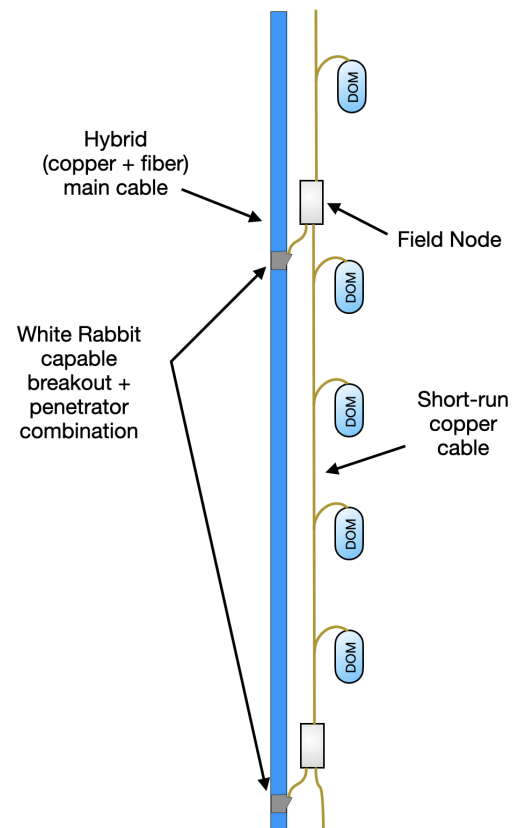


Figure 1: The primary elements of the IceCube-Gen2 Hybrid Fiber/Copper Option